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ALUMINUM ALLOY RIVET

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In the joining of aluminum base alloy parts by means of rivets, the strength of the rivets should be comparable to that of the parts joined. Therefore, in the joining of high strength aluminum base alloys, rivets of corresponding strength are required in order to make a proper joint. The high strength aluminum base alloys are those alloys which are susceptible to having their strength developed by means of a solution heat treatment followed by a natural or artificial aging process. Such solution heat treatments are well known in the art and ordinarily involve heating the alloy at a temperature between 750 and 1020° F., after which it is cooled rapidly or "quenched" by immersion in water or oil, or by a current of air.

The alloys used for making high strength aluminum base alloy rivets are ordinarily those which age-harden spontaneously at room temperature following a solution heat treatment, this treatment being referred to as "natural aging," as distinguished from "artificial aging," which is carried out by heating the metal at an elevated temperature—ordinarily around 250 to 400° F. In riveting operations, it is customary to drive the rivets subsequent to the solution heat treatment, but since more pressure is required for driving the rivets as their strength increases and there is a greater tendency for cracks to develop in the driven head, it is desirable to drive them before aging of the alloy increases the strength of the metal greatly. Alloys which age spontaneously at room temperature may not reach their ultimate properties until a considerable time after they have been quenched following the solution heat treatment. However, the alloys heretofore used for making high strength aluminum base alloy rivets age-harden rapidly enough following the solution heat treatment that the rivets ordinarily soon become too hard to be driven satisfactorily at normal pressures, and consequently the rivets must be driven within a very short time after they have been given a solution heat treatment and been quenched. For example, rivets made of an alloy containing about 4 per cent copper, 0.5 per cent magnesium, and 0.5 per cent manganese, the balance being aluminum plus impurities, must ordinarily be driven within one hour after quenching, or they become too hard and tend to crack at the heads during driving, and must again be given a solution heat treatment before they can be driven. One method which has been used to overcome this difficulty and retard the aging of the rivets has been to store the rivets at low temperatures—for example, a temperature of 32° F. or lower—following their solution heat treatment and quenching, but that procedure increases the expense of using the rivets.

It is an object of this invention to provide an aluminum base alloy rivet which is susceptible to spontaneous aging, but which can be driven satisfactorily at normal pressures over an extended time following a solution heat treatment. It is a further object of this invention to provide an aluminum base alloy rivet which is capable of achieving a considerable increase in strength through spontaneous aging after a solution heat treatment, but which is characterized by an initially slow age-hardening.

It has been discovered that rivets made from an aluminum base alloy containing from 0.75 to 4.5 per cent zinc, from 1 to 3 per cent magnesium, from 1 to 3 per cent copper, when given a solution heat treatment and quenched, not only eventually attain properties upon age-hardening at room temperature which make the rivet satisfactory for applications where high strength and hardness are required, but also initially age-harden slowly after the solution heat treatment, with the result that the rivets can be driven satisfactorily at normal pressures for a considerable time after the solution heat treatment. In the above composition it is desirable that silicon, which is normally present as an impurity in aluminum base alloys, should not exceed 0.5 per cent to obtain the desired initially slow age-hardening.

In addition to the alloying ingredients mentioned above, it is preferred to add to the rivet alloy from 0.25 to 1.5 per cent of manganese, or 0.1 to 0.5 per cent chromium or zirconium, singly or together, to obtain increased strength. A small amount of iron—around 0.1 to 0.6 per cent—is also usually present in the alloy as an impurity.

In the preferred form of the invention, the rivets are made of an alloy composed of from 2.5 to 3.5 per cent zinc, 1.5 to 2.5 per cent magnesium, 1.5 to 2.5 per cent copper, and not more than 0.25 per cent silicon, and if manganese, chromium, or zirconium is present, it is preferred to keep the manganese at from 0.4 to 1.2 per cent, and the chromium or zirconium at 0.2 to 0.3 per cent. This alloy is preferably given a solution heat treatment at a temperature between 900 and 970° F., followed by quenching in cold water.

Rivets made from the alloys described above age-harden slowly enough that they can be driven

without difficulty for at least eight hours, and for as long as twenty-four hours, after solution heat treatment. As an example of the invention, specimens of an alloy consisting of 3 per cent zinc, 2 per cent magnesium, 2 per cent copper, .5 per cent manganese, .2 per cent silicon, and 0.2 per cent iron were heat treated at 950° F. for 30 minutes and then quenched in cold water. Immediately after quenching, the material had a tensile strength of 44,000 pounds per square inch and a yield strength of 18,000 pounds per square inch. The specimens were allowed to age at room temperature for varying periods of time, with the following effect on their properties:

Length of time after quench	Tensile strength	Yield strength
	Lbs. per sq. in.	*Lbs. per sq. in.*
2 hours	44,000	19,000
4 hours	45,000	19,000
6 hours	44,000	20,000
8 hours	46,000	20,000
16 hours	49,000	25,000
24 hours	51,000	27,000
2 months	65,000	41,000

It will be seen from the above table that there is very little increase in strength for eight hours after the solution heat treatment, and even after twenty-four hours, the strength of the specimens had not increased excessively for rivet-driving purposes. Yet, they eventually attain a high degree of strength, being comparable to the present maximum strength obtained by natural aging of any aluminum base alloy.

In addition to age-hardening slowly to a point where they possess properties which are adequate for purposes where strong aluminum alloy rivets are used, the rivets described above also possess good resistance to corrosion and are easily fabricated.

I claim:

1. A solution heat treated rivet composed of an aluminum base alloy containing from 0.75 to 4.5 per cent zinc, 1 to 3 per cent copper, and 1 to 3 per cent magnesium, said rivet being characterized by initially slow age-hardening at room temperature.

2. A solution heat treated rivet composed of an aluminum base alloy containing 2.5 to 3.5 per cent zinc, 1.5 to 2.5 per cent copper, and 1.5 to 2.5 per cent magnesium, said rivet being characterized by initially slow age-hardening at room temperature.

3. A solution heat treated rivet composed of an aluminum base alloy containing 0.75 to 4.5 per cent zinc, 1 to 3 per cent copper, 1 to 3 per cent magnesium, and 0.25 to 1.5 per cent manganese, said rivet being characterized by initially slow age-hardening at room temperature.

4. A solution heat treated rivet composed of an aluminum base alloy containing 0.75 to 4.5 per cent zinc, 1 to 3 per cent copper, 1 to 3 per cent magnesium, and 0.1 to 0.5 per cent zirconium, said rivet being characterized by initially slow age-hardening at room temperature.

5. A solution heat treated rivet composed of an aluminum base alloy consisting of from 2.5 to 3.5 per cent zinc, 1.5 to 2.5 per cent copper, 1.5 to 2.5 per cent magnesium, and 0.4 to 1.2 per cent manganese, the balance being substantially aluminum, said rivets being characterized by initially slow age-hardening at room temperature.

6. A solution heat treated rivet composed of an aluminum base alloy consisting of 2 per cent copper, 2 per cent magnesium, 3 per cent zinc, and 0.5 per cent manganese, the balance being substantially aluminum, said rivet being characterized by initially slow age-hardening at room temperature.

7. A solution heat treated rivet composed of an aluminum base alloy containing from 0.75 to 4.5 per cent zinc, 1 to 3 per cent copper, 1 to 3 per cent magnesium, and 0.1 to 0.5 per cent chromium, said rivet being characterized by initially slow age-hardening at room temperature.

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